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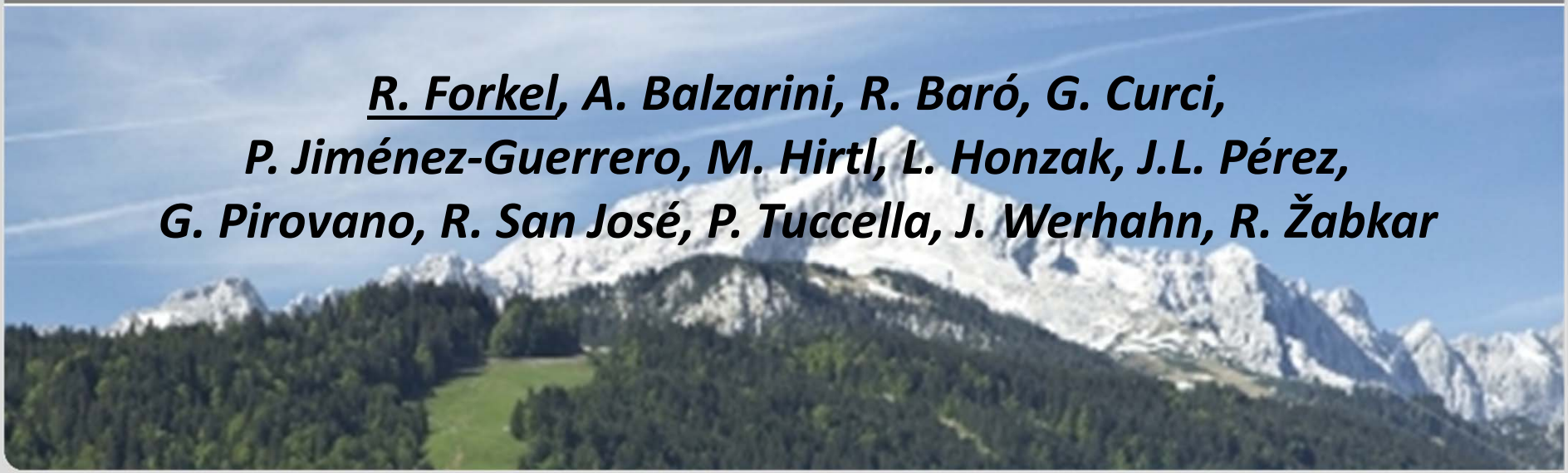
WRF-Chem simulations on the effect of aerosol-meteorology feedback on regional pollutant distributions over Europe



R. Forkel, A. Balzarini, R. Baró, G. Curci, P. Jiménez-Guerrero, M. Hirtl, L. Honzak, J.L. Pérez, G. Pirovano, R. San José, P. Tuccella, J. Werhahn, R. Žabkar

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9th international on Air Quality
24-28 March 2014, Garmisch-Partenkirchen

AQMEII2

AQMEII: **Air Quality Model Evaluation International Initiative**
Initiated by JRC Ispra, US-EPA, and Environment Canada
http://aqmeii.jrc.ec.europa.eu/

First phase: 2010-2011; Atmospheric Environment 53 (2012)

Second phase with focus on **online coupled models**
European Domain: 20 Participants (1 with offline model)
Cost action ES1004 EuMetChem

7 contributions with WRF-Chem with simulations for Europe

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AQMEII2 & WRF-Chem

Contributions with WRF-Chem

1) Univ. L'Aquila, CETEMPS (Gabriele Curci, Paolo Tucella)

2) RSE (Guido Pirovano, Alessandra Balzarini)

3) Univ Murcia, MAR-UMU (Pedro Jiménez-Guerrero, Rocio Baró)

4) KIT, IMK-IFU (Renate Forkel, Johannes Werhahn)

5) Univ. Pol. Madrid, ESMG (Roberto San José, Juan L. Pérez)

6) Univ. Ljubliana SPACE-SI (Rahela Žabkar, Luka Honzak)

7) ZAMG (Marcus Hirtl)

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Coordinated WRF-Chem simulations

- Spontaneous movement intended to minimize efforts of groups running WRF-Chem over Europe with contribution to pre- and post-processing and code additions from everyone
- Coordinated effort with identical domain and preprocessing
- Coordinated set of model parameterizations, in order to analyze differences in simulations 1 change per time (not always possible though …)

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AQMEII2 WRF-Chem chemical/microphys. options

	Ljubljana	Ljubljana	KIT	ZAMG	Murcia	L'Aquila	RSE	Madrid
Version	3.4.1	3.4.1	3.4.1	3.4.1	3.4.1	3.4 with 3.5 VBS	3.4.1	3.4.1
Microphys.	Morrison	Morrison	Morrison	Morrison	Lin	Morrison	Morrison	Morrison
Gas chem.	RADM2	RADM2	RADM2 Integ1mod	RADM2	RADM2	RACM	CBMZ	CBMZ
Inorg. aerosol	MADE	MADE	MADE	MADE	MADE	MADE	MOSAIC 4 bins	MOSAIC 4 bins
Org. aero	SORGAM	SORGAM	SORGAM	SORGAM	SORGAM	VBS	-	-
GS wet.dep	Simple	Simple	Easter04	Easter04	Easter04	Easter04	Simple	Easter04
Conv. w.dep	yes	yes	yes	yes	yes	yes	yes	yes
GS aq. chem	-	-	WT86	FP01	FP01	WT86	-	FP01
Conv. aq.ch	WT86	WT86	WT86	WT86	WT86	WT86	-	-
Aero dir eff	No	Yes	Yes	Yes	Yes	Yes	No	Yes
GS aero indir effect	No	No	Yes	Yes	Yes	Yes	No	Yes
Other								No dust

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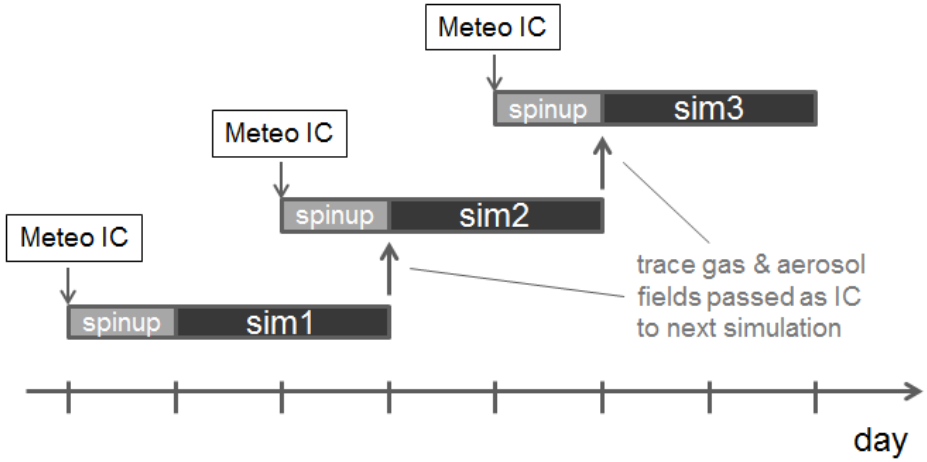
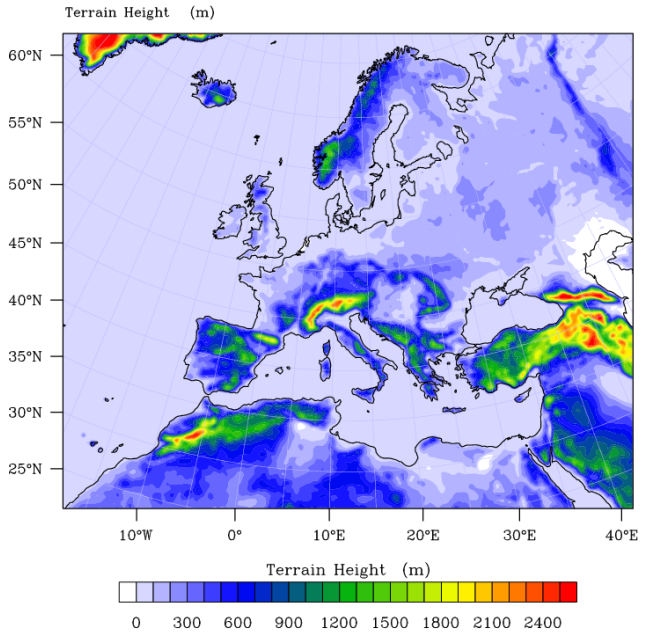
General Setup



AQMEII recommend:

- 1-day meteo-only spin-up +
- 2-days simulations with chemistry
- Chemistry restarted from previous run

Long enough to allow feedback ↔ short enough for suppressing semi-direct effects?



WRF/Chem version 3.4.1 with common modifications (one simulation with 3.5)

- Lambert projection (50N, 12E)
- 270 x 225 cells, dx = 23 km
- 33 eta levels

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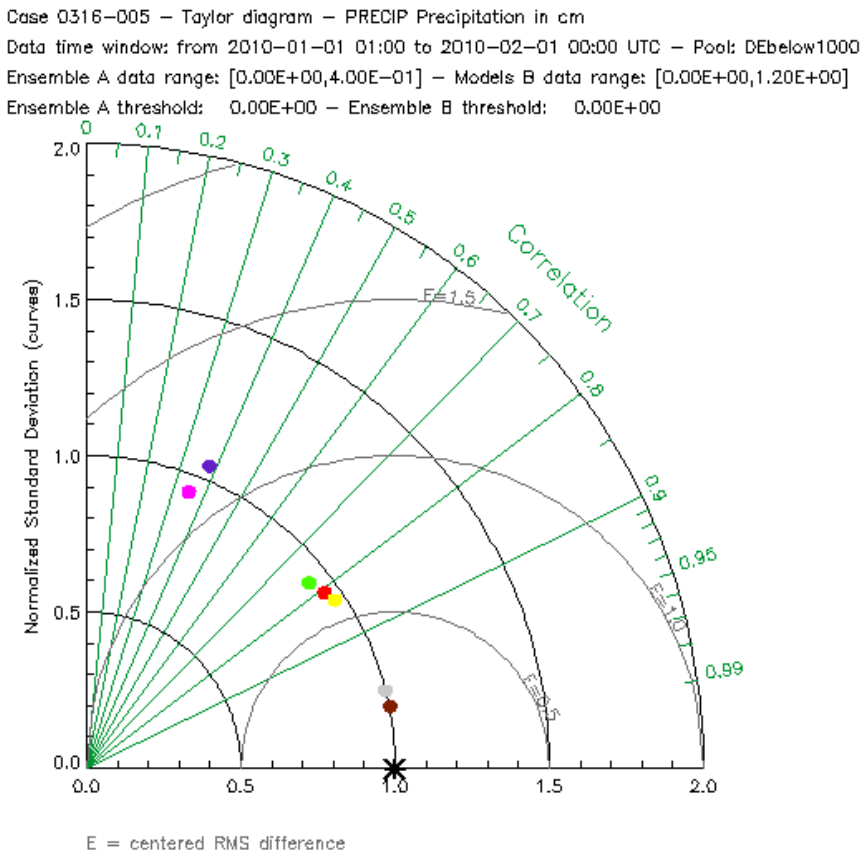
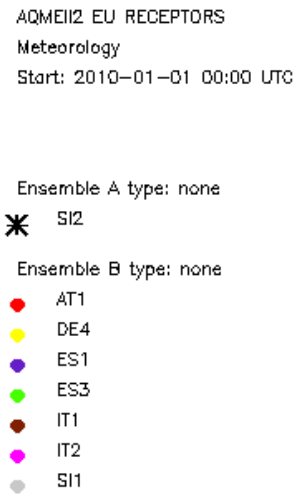
Magnitude of feedback effects





Precipitation over Germany January 2010 (Only at AQ stations!)

Decrease of precipitation due to indirect effect (increase of precipitation due to indirect effect can occur for very clean conditions)

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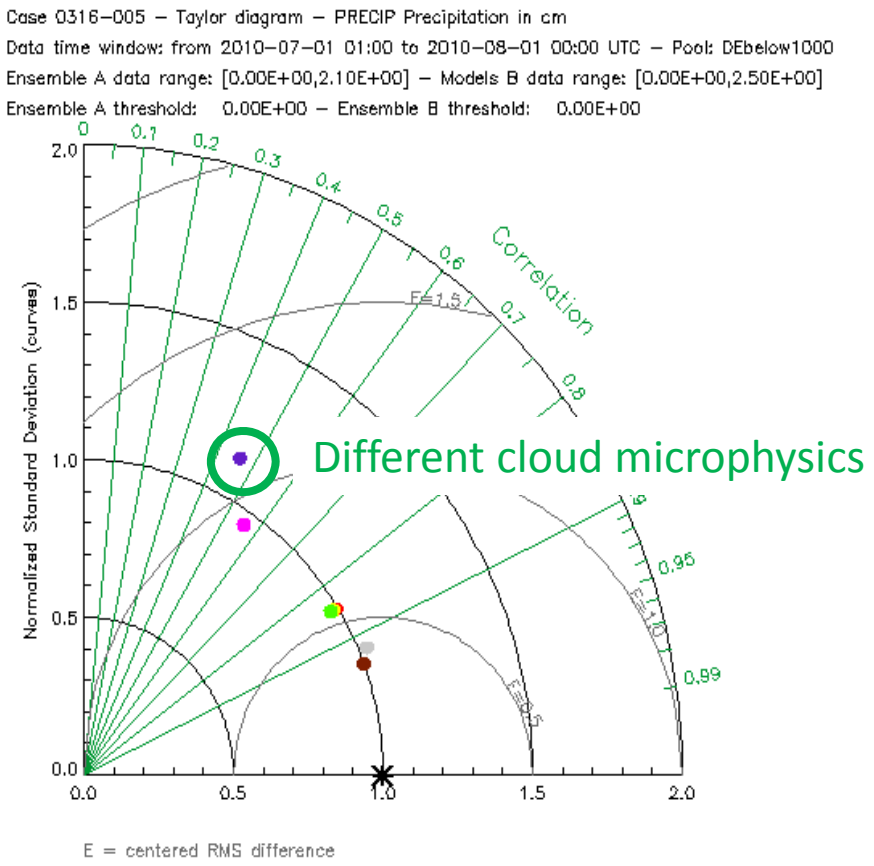
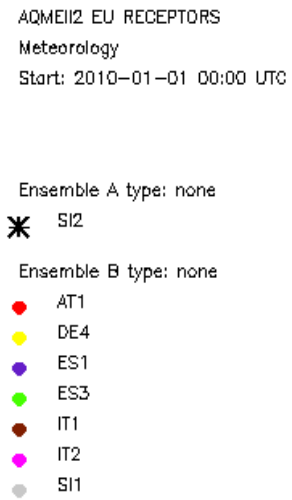
Magnitude of feedback effects





Precipitation over Germany July 2010
(Only at AQ stations!)

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Solar radiation: July 2010

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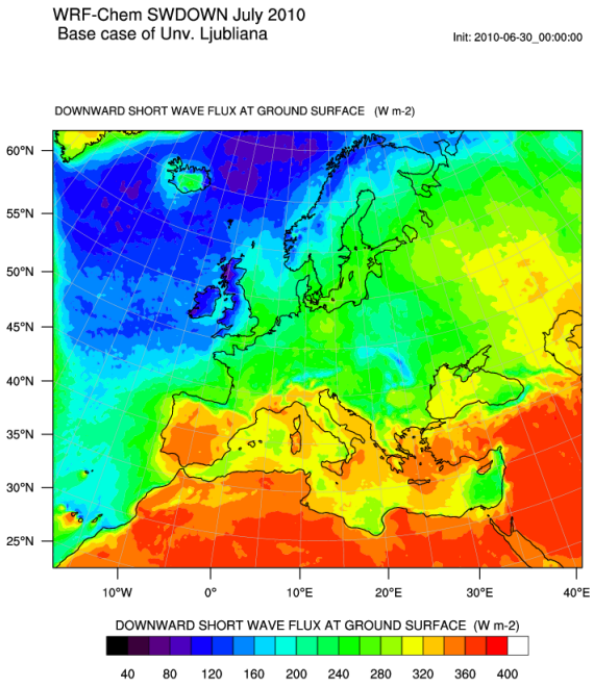
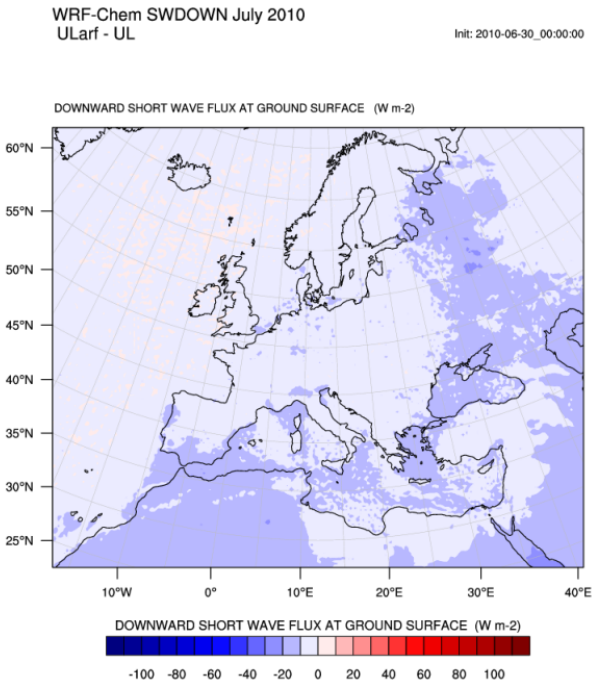
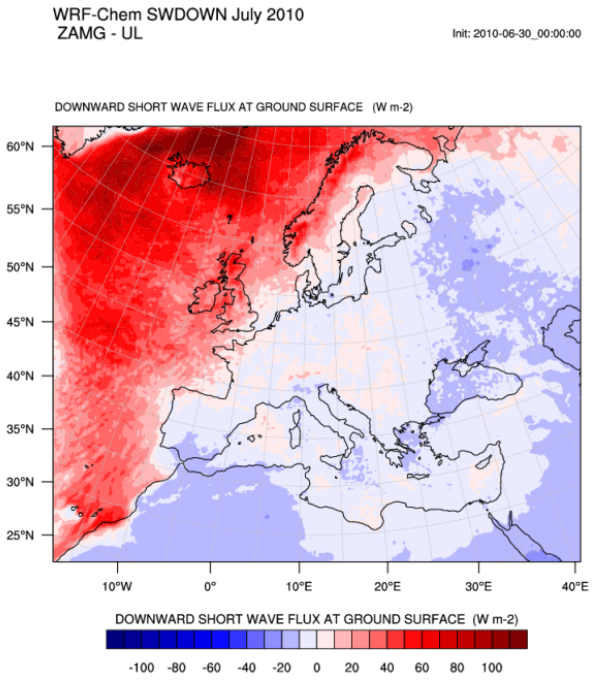
Baseline



Difference direct - base



Diff. (dir + indir) - base



Almost no difference for different simplified liquid phase chemistry

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Temperature: July 2010

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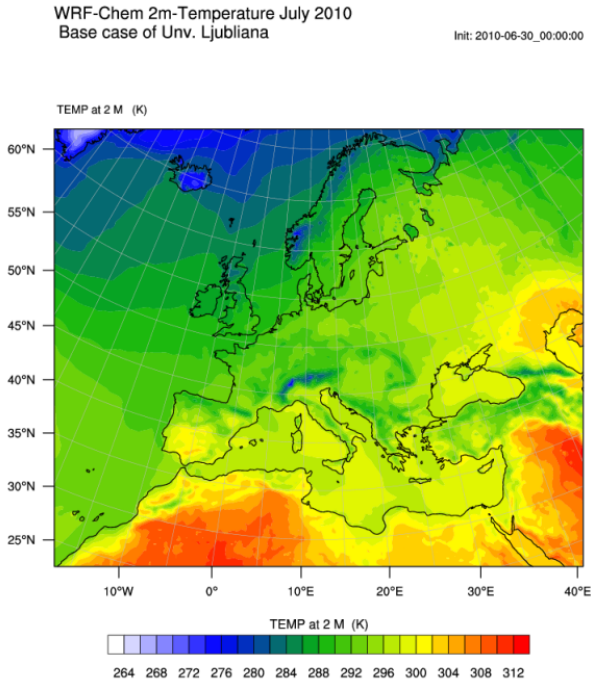
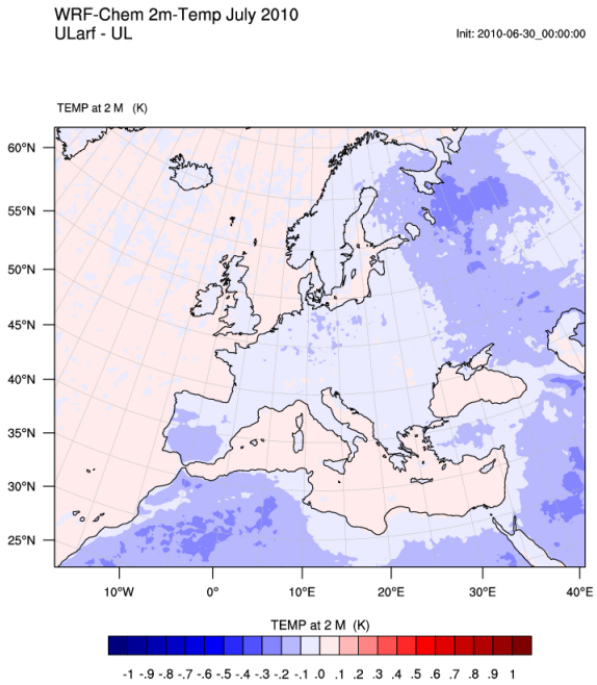
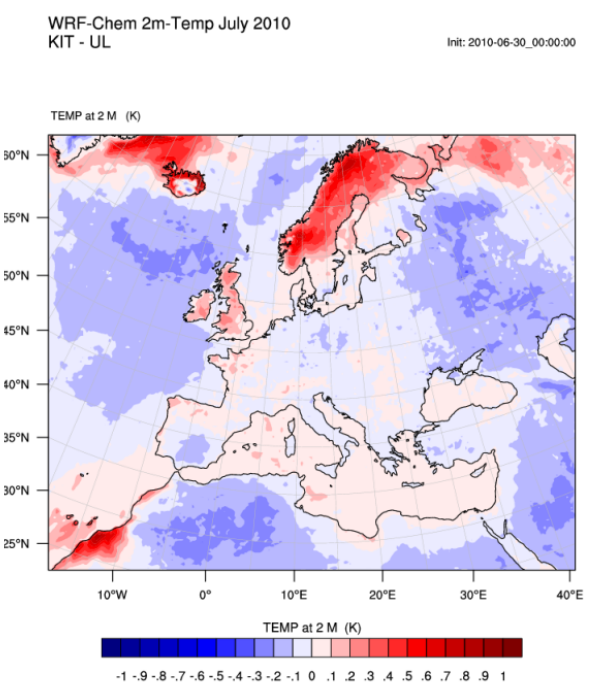
Baseline



Difference direct - base



Diff. (dir + indir) - base



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PBL height: July 2010

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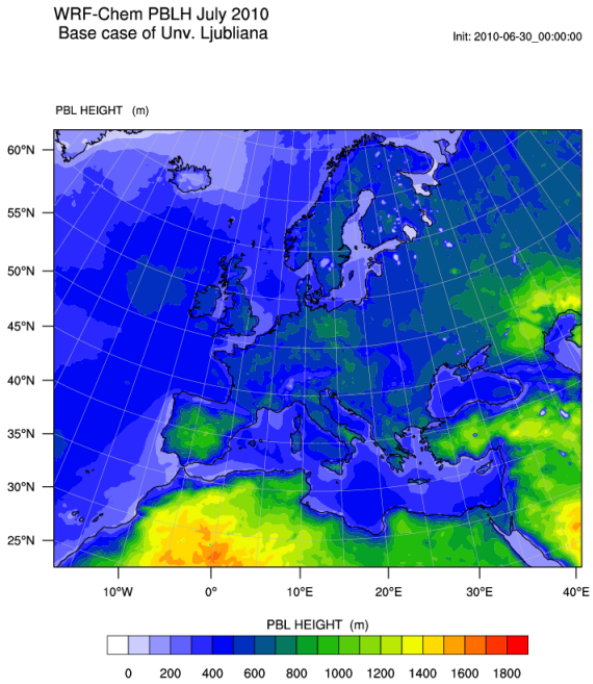
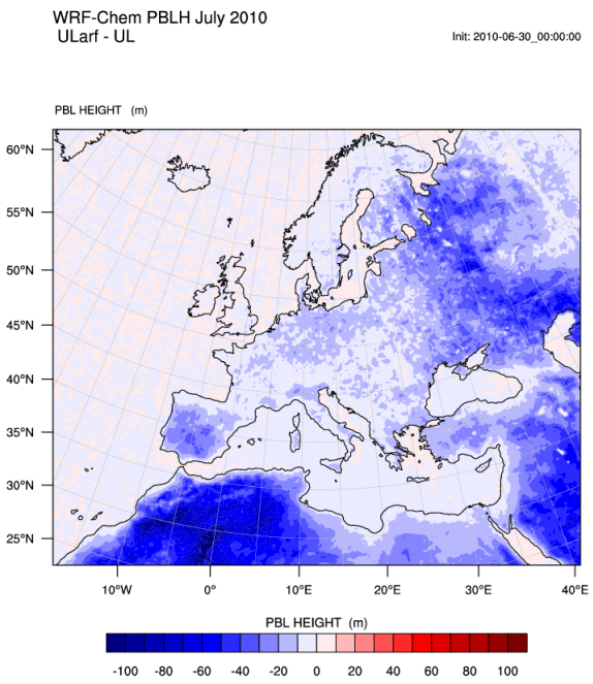
Baseline



Difference direct - base



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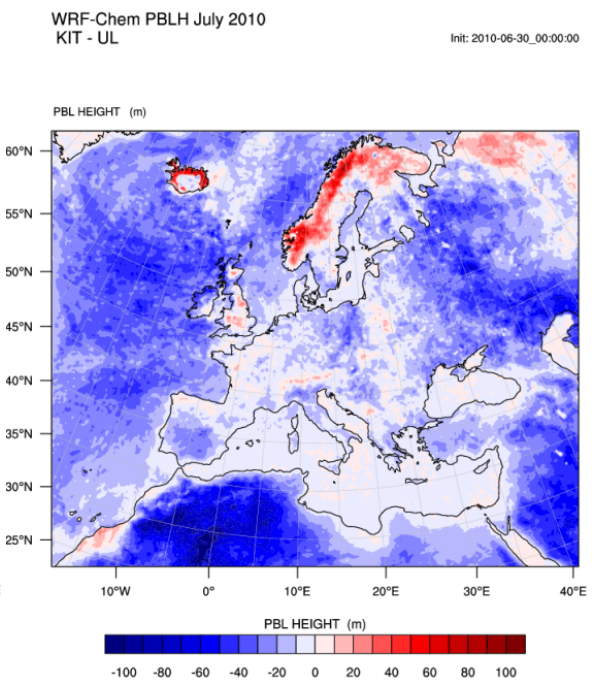

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Precipitation: July 2010

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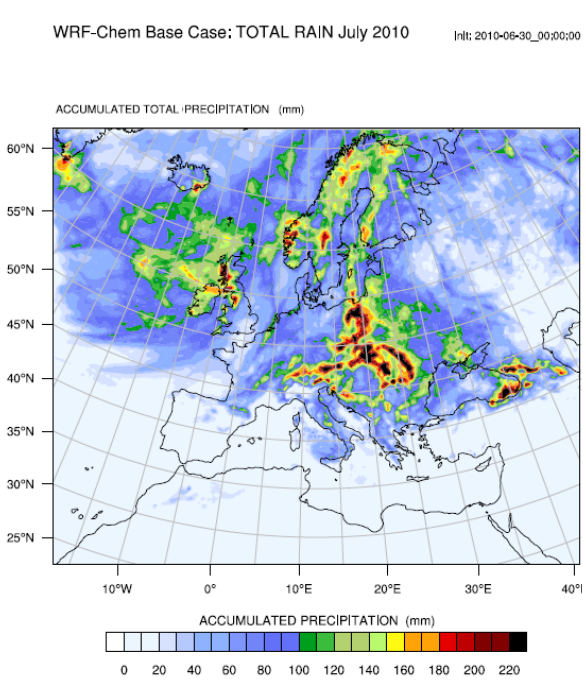
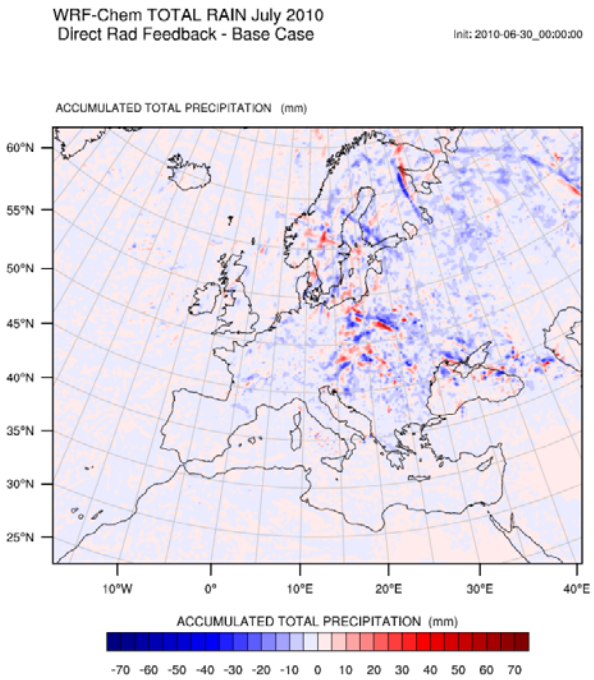
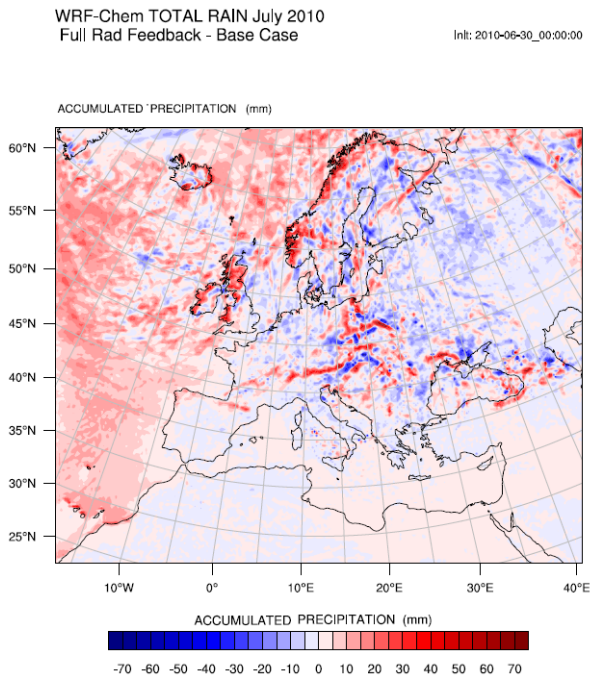
Baseline



Difference direct - base



Diff. (dir + indir) - base



Indirect effect: increase mostly for regions with low CCN concentratations.
Differences depend on assumed CCN concentration for baseline

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PM10: July 2010

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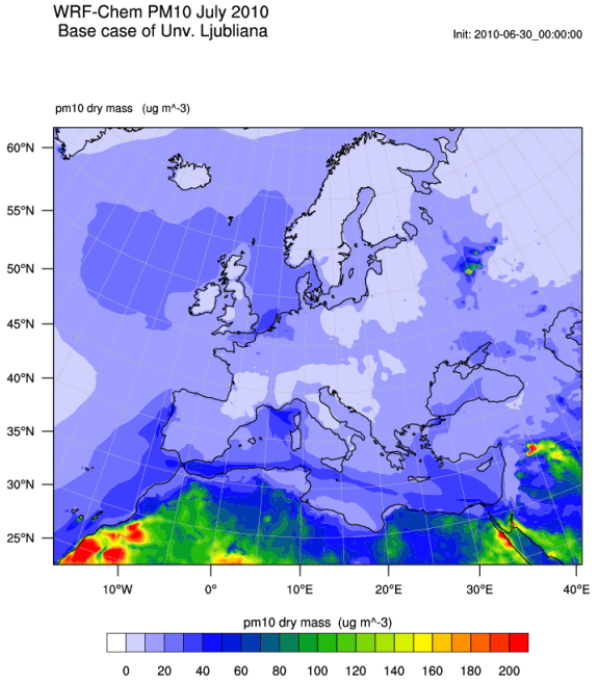
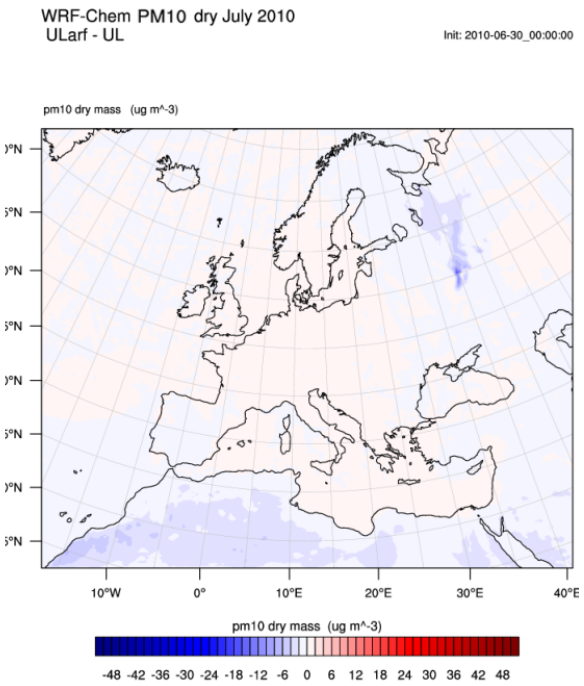
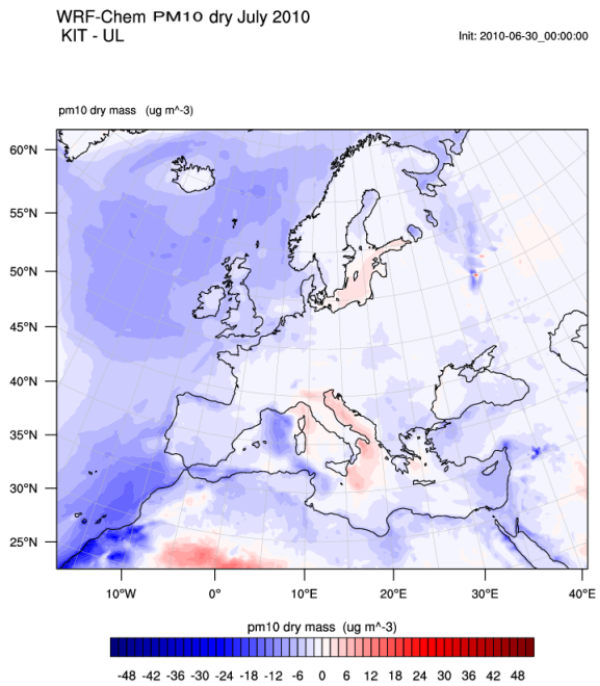
Baseline



Difference direct - base



Diff. (dir + indir) - base



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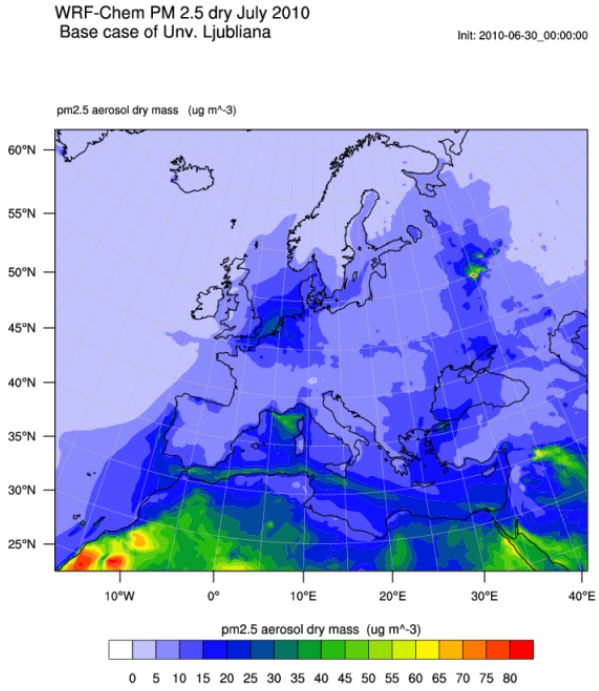
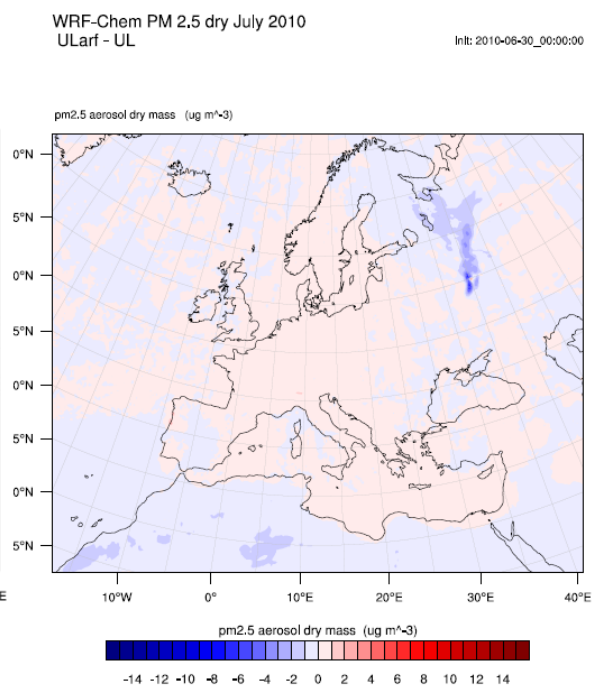
PM2.5: July 2010

Baseline



Difference direct - base



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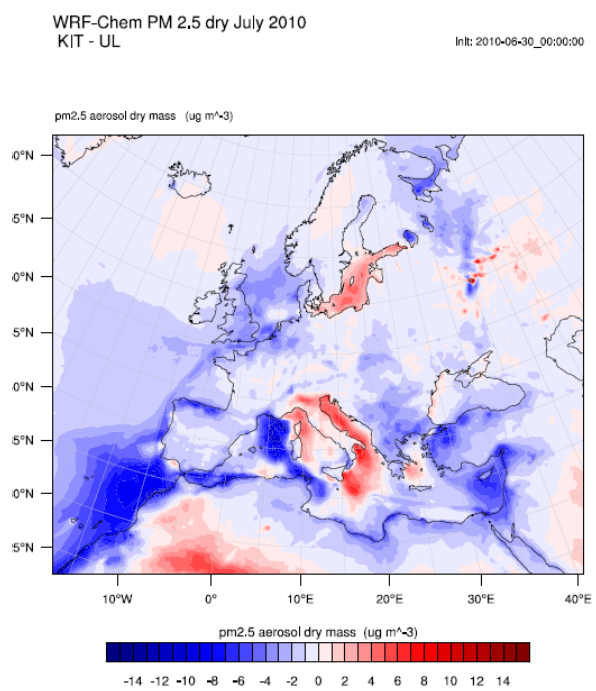

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Ozone: July 2010

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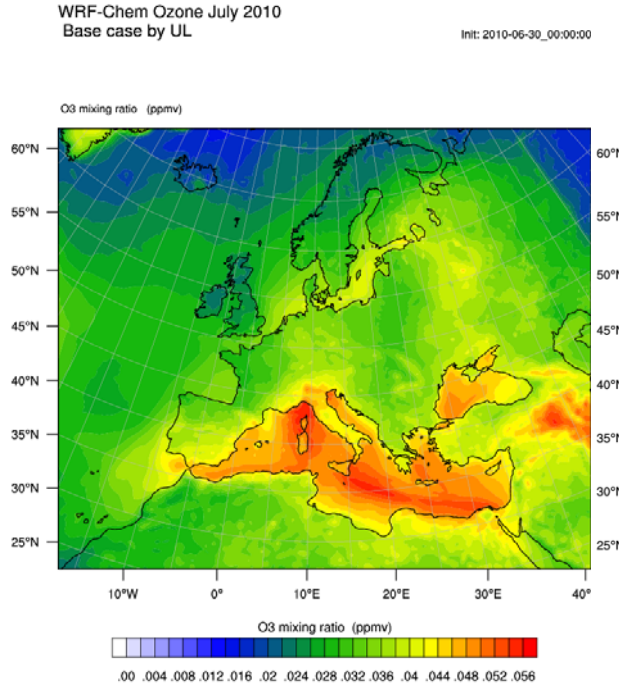
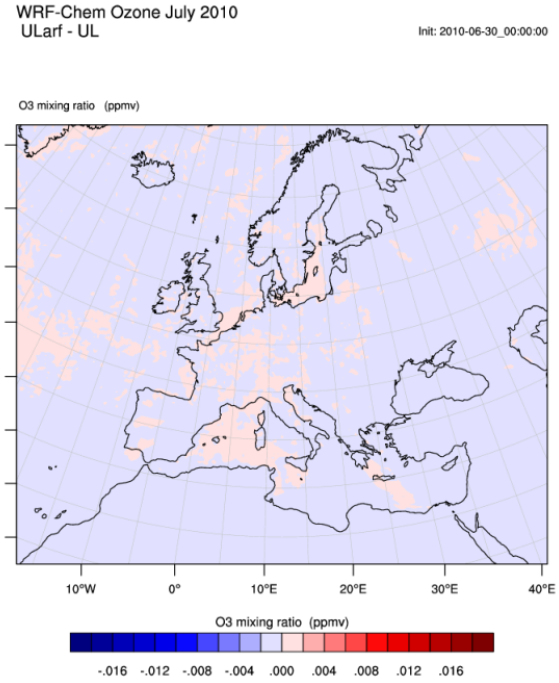
Baseline



Difference direct - base



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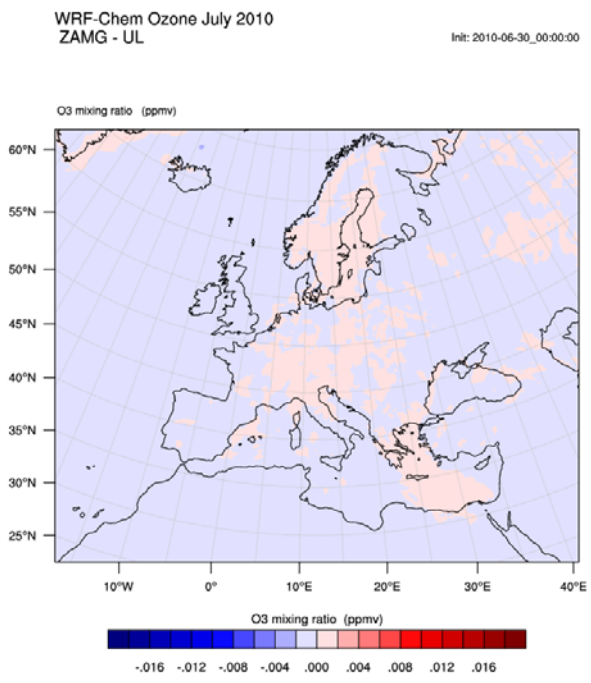

Only small effect of feedback, much larger effect of mechanism

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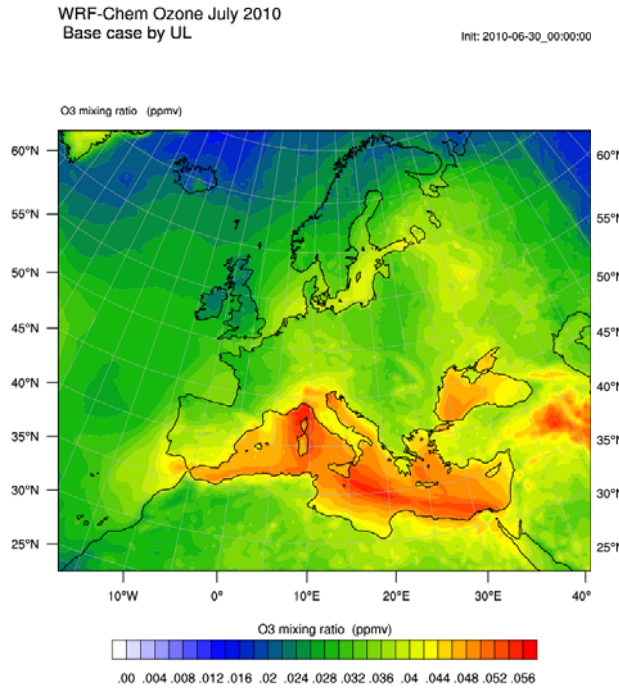
Baseline



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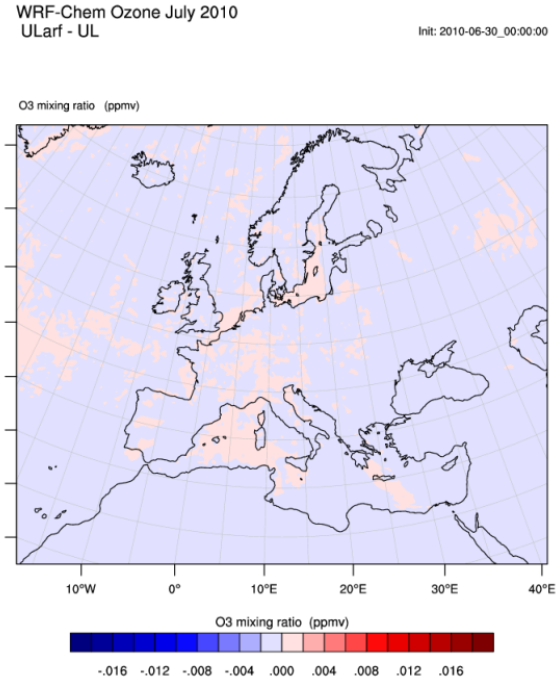
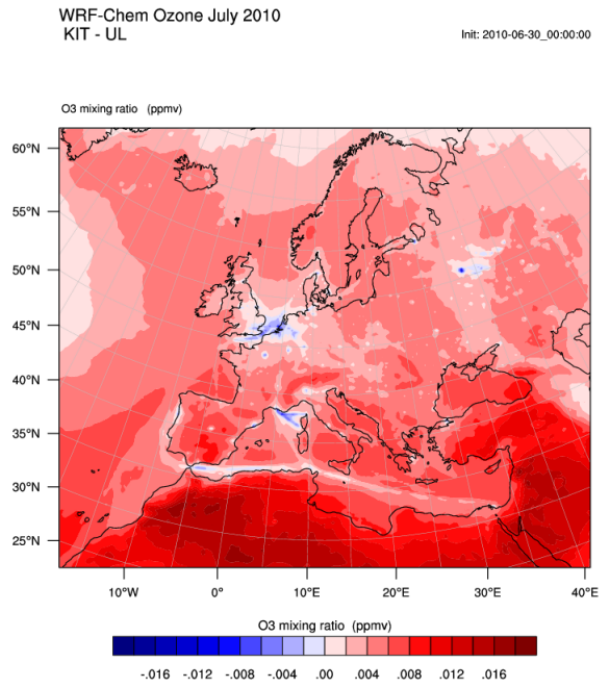


Diff. (dir + indir) - base



Only small effect of feedback, much larger effect of mechanism

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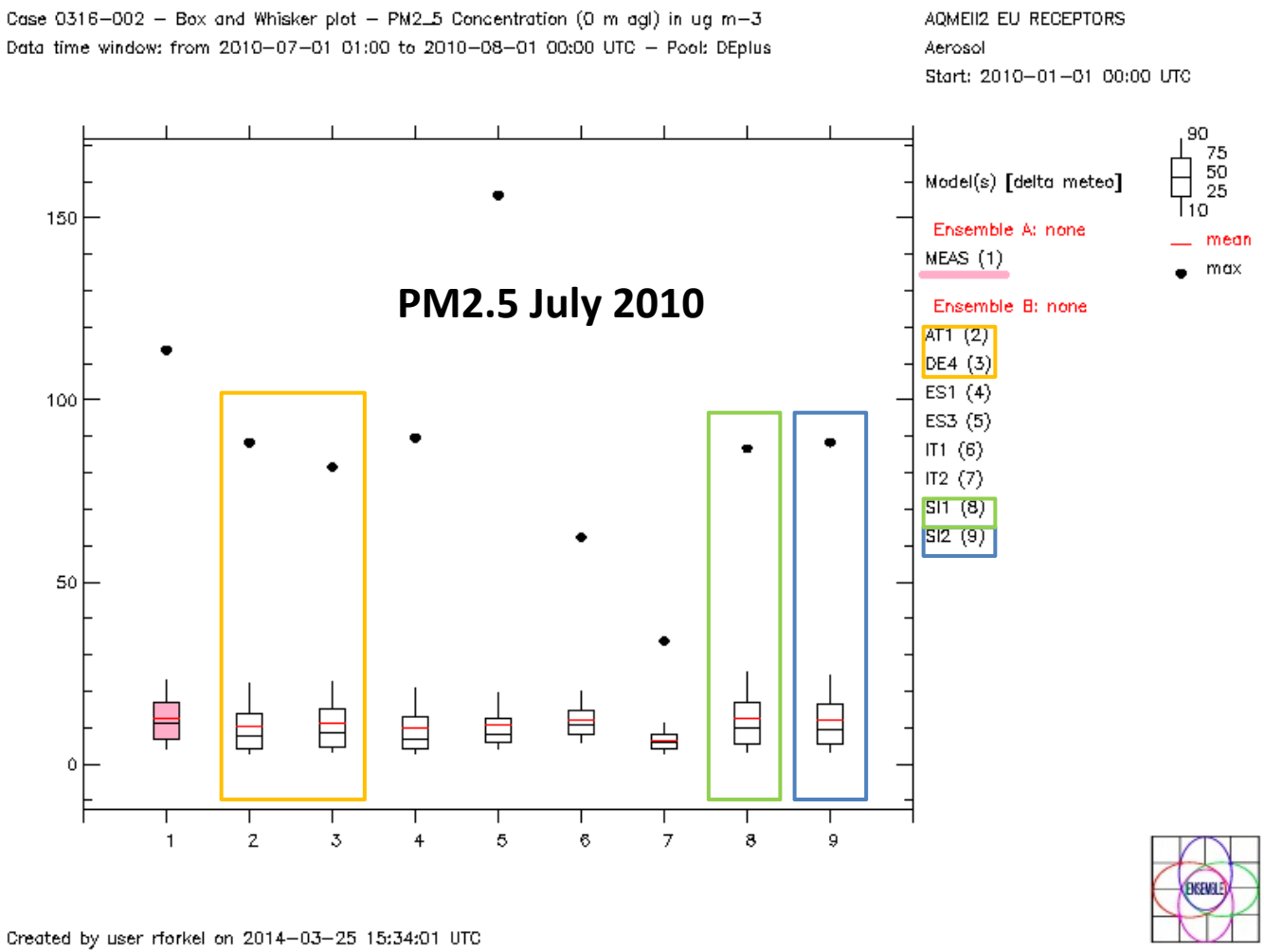
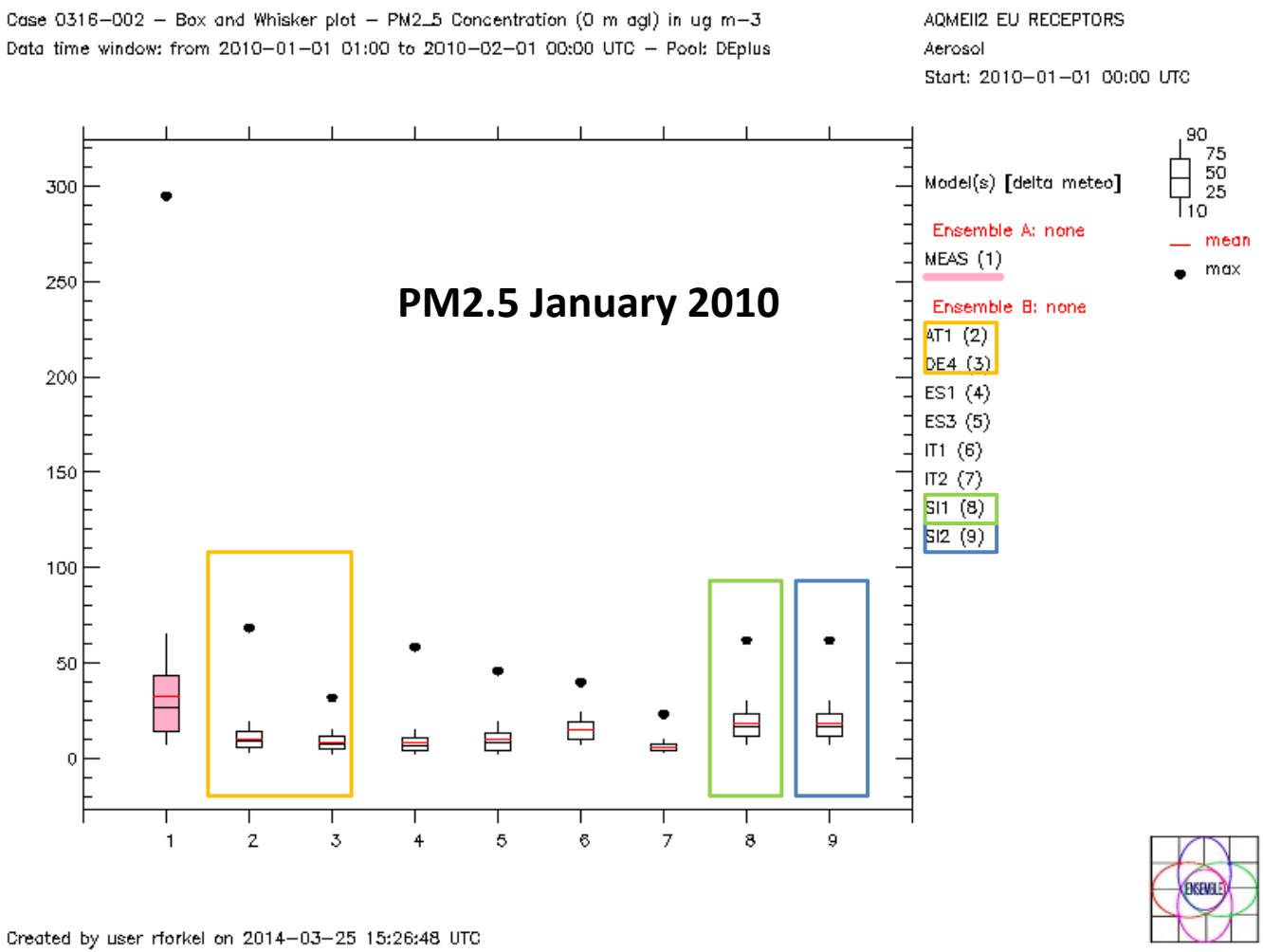
Did feedback improve simulations?



Did feedback improve simulations?



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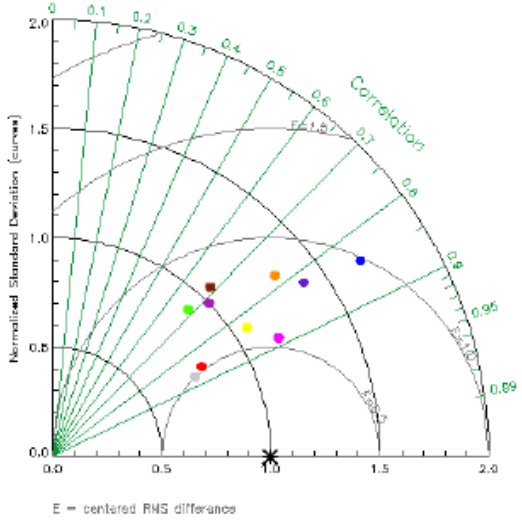
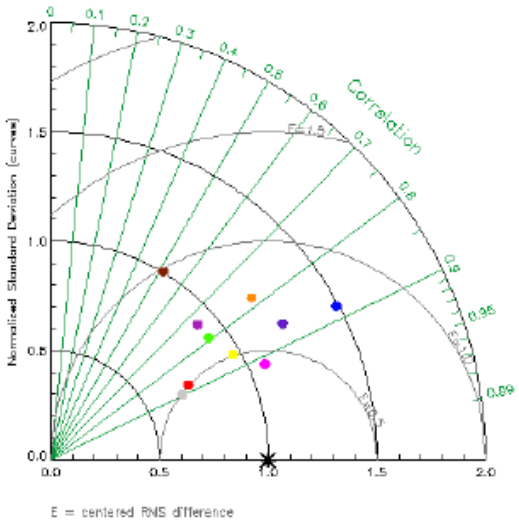
Ozone: comparison with observations

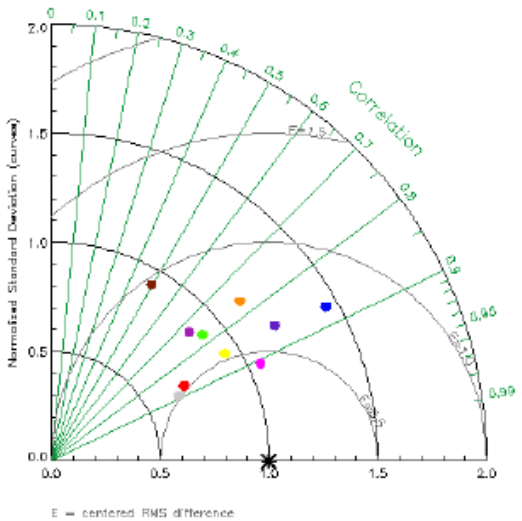
RURAL

URBAN

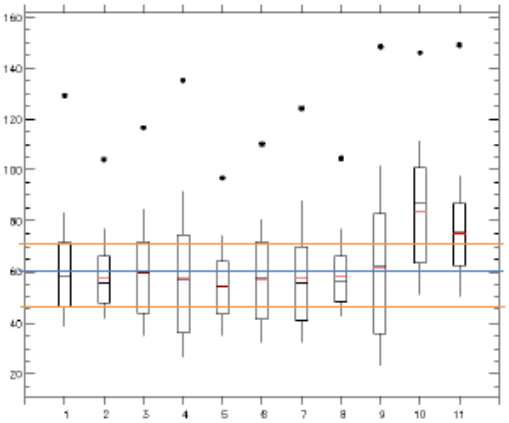
SUBURBAN

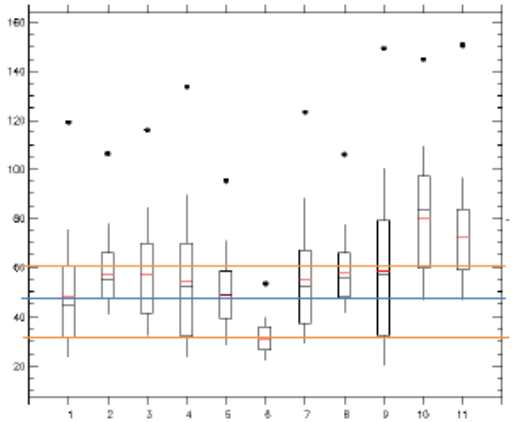






AT1
DE4
ES2a
IT1
IT2
NL2
SI1
UK4oldrun
UK5
BG1





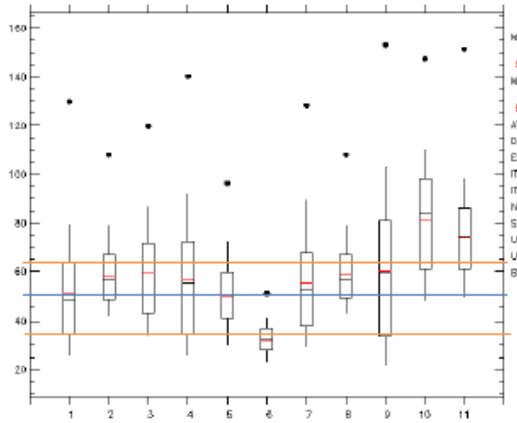


Figure by Ulas Im, JRC

Conclusions

- Joint effort for AQMEII2 with common grid and input permits analysis of feedback effects on meteorology
- For the applied horizontal resolution, the impact of aerosol feedbacks on pollutant distributions was frequently smaller than the effect of the choice of the chemistry mechanism and aerosol module, and microphysics scheme.
- No ‘best’ setup
- Differences depend on the parameters of the ‘base case’ and consiered region (here, inclusion of indirect effect can reduce/enhance precipitation)
- Complete analysis of the indirect effect may require simultions with higher resolution
- Cases could have been even more…

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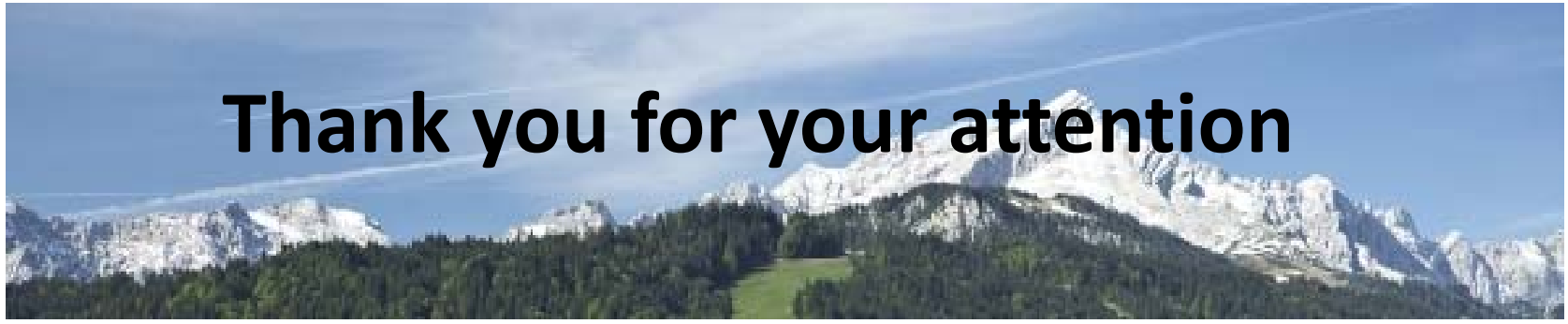
Acknowledgments:

- All groups for their contributions to code, pre- and post-processing
- UL for the space on their FTP server

- TNO (anthropogenic emissions database): Hugo Denier van der Gon
- ECMWF/MACC project & Météo-France/CNRM-GAME (chemical boundary conditions)
- FMI (fire emissions)
- Joint Research Center Ispra/Institute for Environment and Sustainability (ENSEMBLE system): Ulas Im, Stefano Galmarini
- Enviroware (ENSEMBLE system): Roberto Bianconi
- Cost action ES1004 EuMetChem: Alexander Baklanov



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